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Forum Comment

Early Cambrian metazoans in fluvial environments, evidence of the non-marine Cambrian radiation

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Kennedy and Droser (2011) proposed that the colonization of non-marine depositional environments occurred much earlier than previously thought. Prior sedimentological interpretation of the trace-fossil bearing succession of the middle member of the Wood Canyon Formation (Diehl, 1979; Fedo and Cooper, 1990; Fedo and Prave, 1991) is used by Kennedy and Droser to infer that metazoan organisms colonized fluvial depositional settings early in the Cambrian. That metazoans could have overcome the physiological challenges of life in freshwater (Maples and Archer, 1989) within the first ~20 m.y. of their evolution at the base of the Cambrian (Brasier et al., 1994) would be quite remarkable. The claims of Kennedy and Droser thus require close examination.

In tide-dominated depositional systems, the presence of tidally modulated currents is not conclusive evidence of brackish water since the tidal reach commonly exceeds penetration of the saline wedge (McIlroy, 2004b). The ichnological proxies most commonly used to invoke salinity stress in marginal marine settings are small trace-fossil size and low ichnological diversity coupled with intense bioturbation (Buatois et al., 2005). Ichnologists studying the Cambrian have to contend with the non-uniformitarian nature of both benthic ecology, including small burrow size (e.g., McIlroy and Logan, 1999), and rapid sediment delivery by fluvial systems developed in the absence of plants (Diehl, 1979; Fedo and Cooper, 1990; Fedo and Prave, 1991).

In order to invoke non-marine conditions based on ichnological evidence, some baseline norm must be established (essentially what would a normal assemblage look like) and rigorous sedimentological observations must be integrated objectively with the ichnological data (McIlroy, 2008). The low-diversity ichnological assemblage of Kennedy and Droser includes the inferred suspension feeding burrows *Skolithos* and *Arenicolites*, along with deposit-feeding *Psammichnites*, taxa normally considered fully marine in the Cambrian. *Psammichnites* has not been previously reported from non-marine facies (Seilacher, 2007). *Arenicolites* and *Skolithos* are common components of marine ichnological assemblages in the Cambrian (Droser, 1991; McIlroy and Garton, 2010). The trophic mode of the *Skolithos* trace makers is conventionally inferred to be suspension feeding, as Kennedy and Droser state. However, recent studies of modern burrows of similar form document a range of possible behaviors (Herringshaw et al., 2010) that might be used to explain vertical burrows in settings without significant suspended organic matter. Kennedy and Droser seem not to consider that small burrows in low abundance are conventionally interpreted as burrows of juvenile organisms rather than opportunistic organisms adapted to salinity stress. Preservation of ichnofabrics with small *Skolithos* is common where sedimentation rates are high (McIlroy, 2004a). I consider that there is nothing unusual about the assemblage presented by Kennedy and Droser, and that it is more likely to be a normal Cambrian marine ichnological assemblage associated with high rates of sediment supply.

The second line of argument Kennedy and Droser use to infer a fluvial depositional setting is the prior interpretation of the middle member of the Wood Canyon Formation as a classic fluvial braid plain (Diehl, 1979; Fedo and Cooper, 1990; Fedo and Prave, 1991). The new ichnological discoveries in the Wood Canyon Formation (Kennedy and Droser) open up two possibilities:

1) That published paleoenvironmental interpretations are correct, and the Wood Canyon Member documents a much older non-marine trace fossil assemblage than has been previously documented (Diehl, 1979; Fedo and Cooper, 1990; Fedo and Prave, 1991; Kennedy and Droser).

2) That previous studies (Diehl, 1979; Fedo and Cooper, 1990; Fedo and Prave, 1991) did not recognize marine trace fossils, which could be used to infer that the fluvial braid plain passed distally into a marine basin to produce a braid delta (cf. McPherson et al., 1987). Marine trace fossils in braid deltas are likely to be found in finer-grained distributary channel fills during periods of seasonally low fluvial discharge. This marginal marine interpretation would be consistent with the ichnology and sedimentology presented (Kennedy and Droser), particularly the reports of herringbone cross stratification.

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